STORMWATER STUDY
HAZEL RUN WATERSHED
SPOTSYLVANIA COUNTY, VIRGINIA

VCRMP GRANT
NO. NA270Z0312-01

Prepared by:

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FINAL DRAFT
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Executive Summary

Review of Problem

Spotsylvania County is looking to alleviate flooding problems in the Hazel Run watershed. Currently, two to three major storms per year contribute to major flooding in parts of the seven square mile watershed that includes Spotsylvania Mall and the Route 3 corridor west of Interstate 95. Flooding in low lying areas within the City of Fredericksburg has been identified through a 1989 study for the city, where the major problems are thought to stem from upstream development in the mall area with little or no runoff restrictions in the past.

Spotsylvania County also lacks a defined flood plain along Hazel Run. A defined flood plain is useful to the county in placing development restrictions on property that may suffer property damage in a flood event. This study includes defining main stream flood plains for that purpose.

Analysis

J.K. Timmons & Associates collected field information for the study including aerial topography, stream surveys, and stream morphology. This information was used to analyze the run generated by current development levels. These flows were then compared to the flows that would have occurred in the Hazel Run Watershed prior to any development in the area (called predevelopment flows). All stormwater management structures considered would be designed to reduce today's flows to predevelopment levels.

The flow analyses revealed that today's level of stormwater flows has increased over predevelopment flows by 10-15%. This relatively small increase is due in large part to two factors, the shape of the Hazel Run watershed and existing basins that occur within the watershed. The elongated shape of the watershed affects the travel time for the stormwater, while existing basins, such as the one in Carriage Hills, currently retain runoff from storms that were once allowed to flow unimpeded.

Alternatives

Several alternatives were analyzed to reduce the rate of flow throughout the watershed and at Hazel Run's entrance into the City of Fredericksburg. The alternatives included main stream and non-perennial channel retention facilities. The high cost associated with the alternatives however, together with the relatively small reduction in runoff (10-15%) caused these alternatives to be

considered not cost effective.

The Altoona Subdivision located near the Spotsylvania Mall outfall channel has had a history of spot erosion, and has received complaints from homeowners in the past. The analysis has shown that while there is little significant increase in 2- and 10-year flood flows, the higher-frequency low-volume storms have increased due to the Spotsylvania Mall area development. Coupled with the natural erodibility of "fall line" streams, the channel outfall from the mall watershed would be best served by streambank stabilization to preserve the bank integrity of this channel into the City of Fredericksburg.

Recommendations

A summary of recommendations follows:

1) With no significant flooding or erosion problems, development in the Hazel Run Watershed can best be controlled through a Stormwater Management Ordinance.

2) The County should maintain the existing retention facilities to include ponds and lakes that currently exist in the watershed, while limiting future development to existing runoff conditions downstream.

3) The Spotsylvania Mall outfall should be stabilized to prevent further low volume storm erosion though a cooperative effort with the City of Fredericksburg.

PURPOSE

The purpose of this Study is to provide the County of Spotsylvania with a management program to control flooding and property damage, soil loss and point and nonpoint source pollution due to stormwater runoff in the Hazel Run watershed in Spotsylvania County, Virginia.

WATERSHED DESCRIPTION

The Hazel Run watershed is located primarily in the Hazel Run and Courtland districts of Spotsylvania County. The area of this study is bound on the north by Route 3 (Germanna Highway), on the west by Routes 620 and 639 (Harrison and Leavell's Road, respectively), on the south by Route 208 (Courthouse Road), and on the east by U. S. Route 1 and the Fredericksburg City Limits.

The Watershed is composed of three major branches or *subwatersheds*, the upper tributary that collects runoff from the Route 3 corridor, Hazel Run, and Long Branch. Each of these subwatersheds will be described in more detail in the following sections.

Of particular concern to both the County and the City of Fredericksburg is the impact of Spotsylvania Mall development in the upper tributary that feeds Hazel Run. This report refers to this tributary as the *Spotsylvania Mall Tributary*. The development of the mall with no impoundment structures, along with other commercial development along the Route 3 corridor has raised the question as to its impacts on the erosion of downstream channels.

The study area contains in its reaches some 5015 acres, most of which fall in the limits of Spotsylvania County. This area contains a mix of development ranging from varying density residential developments to commercial and industrial corridors. The study area is comprised of the three major tributary branches. For this study, these branches are called the Spotsylvania Mall, Hazel Run, and Long Branch tributaries.

These three major branches of the Hazel Run watershed converge in the City of Fredericksburg, at which point Hazel Run continues for nearly three miles before feeding the Rappahannock River just south of downtown Fredericksburg.

Spotsylvania Mall Tributary

The Spotsylvania Mall tributary drains 960 acres and is the northernmost tributary in the study. This east to west tributary is bound most approximately to the north by Route 3 and it extends west to Salem Elementary School. This tributary is fed by the commercial corridor fronting Route 3 and enters a closed system under the parking lot of Spotsylvania Mall. It returns to open channel flow prior to crossing Interstate 95 just south of its ramps at Route 3. The flow, now in the City of Fredericksburg, travels just south of the Altoona subdivision upstream of its confluence with Hazel Run.

The development makeup of the Mall tributary is predominantly commercial along the Route 3 corridor, where development is currently 80% built out. A portion of the Shannon Green development, north of Route 3 and in Fredericksburg, contributes to the runoff in this tributary. South of the corridor, the development becomes primarily medium density single family housing. The average imperviousness over the Mall tributary is estimated to be 31%.

Three BMP's exist in the Mall tributary, both in the vicinity of the Maple Grove subdivision. One is 2.8 acres and lies directly south of Waverly Village Drive, just upstream from Village Square Shopping Center. The second lies approximately 2700 feet upstream in Maple Grove, and covers 1.4 acres.

The third is a BMP to serve the south portion of the mall. Under construction at the time of the study, the hydraulic computations included the BMP as an existing structure for purposes of determining stormwater flows.

Hazel Run Tributary

The central branch is called the Hazel Run tributary. At 1850 acres, this watershed contains 37% of the study area's coverage. It runs from its headwaters near the Five Mile Fork intersection at Route 3 flowing east roughly parallel to Harrison Road to its junction with Long Branch west of Interstate 95.

With the exception of the uppermost reaches of this tributary

being commercial land use, roughly 90% of Hazel Run falls in residential planned areas. Of this area, approximately 27% has been constructed at the time of this study. The relatively low impervious percentage (10.7%) for Hazel Run reflects the modest development over the majority of this watershed.

There are no retention facilities in existence in the main stream of Hazel Run. In the upper reach, new development includes retention facilities to regulate the runoff. These developments include the Summerlake and Queens Mill sections. Retention facilities are also in place in the new Kingswood development as well as the established Beauclaire Plantation.

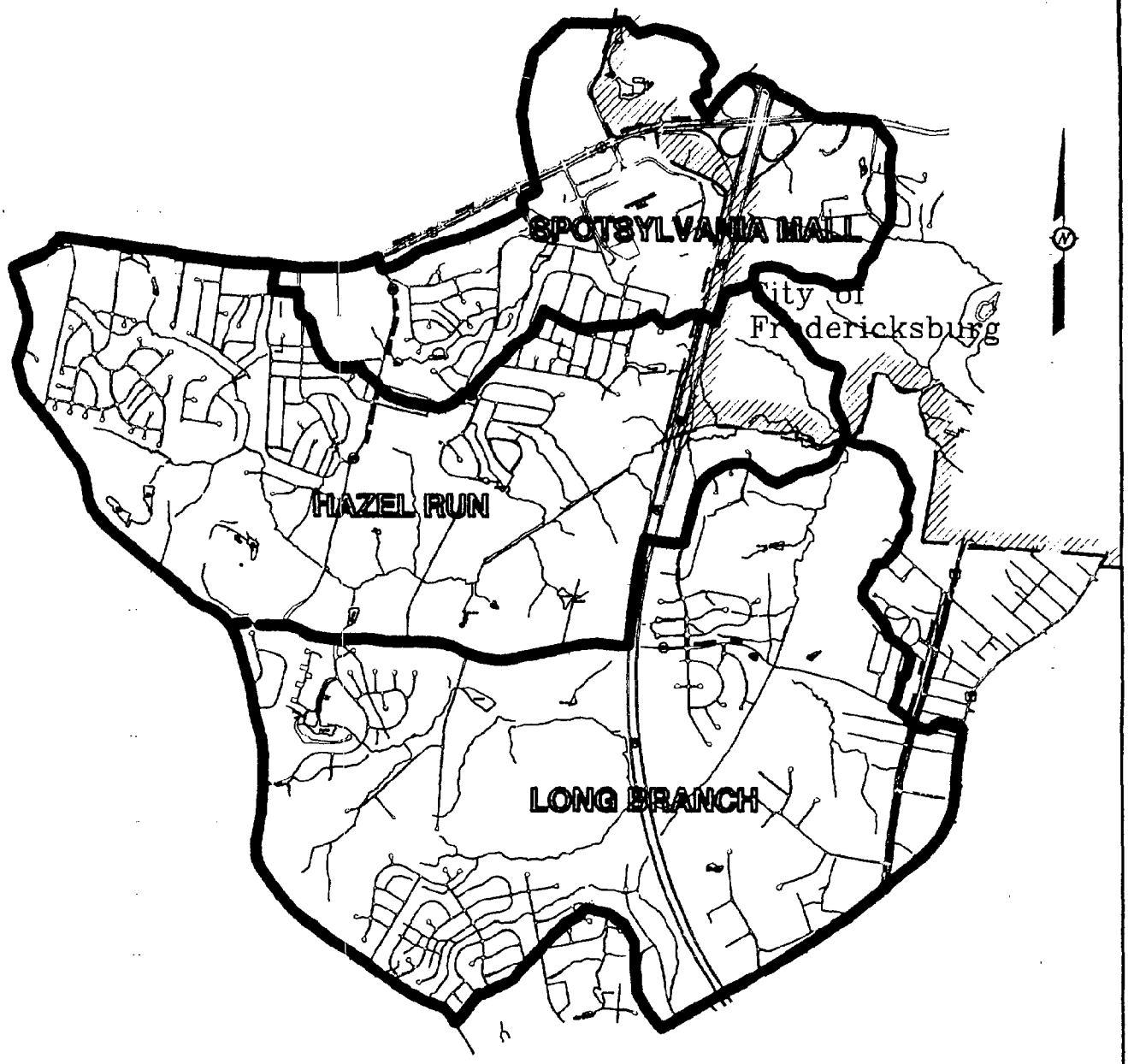
Long Branch Tributary

The Long Branch Tributary is the southernmost tributary of the study area. It flows west to east between Leavell's Road and Interstate 95, then turns north to its junction with Hazel Run. Its area is the largest of the study at 2200 acres.

To the west of Interstate 95 and south of Harrison Road, Long Branch contains much of the single family development as does Hazel Run. This development includes some multiple family as well as detached home subdivisions.

The Long Branch tributary can be divided into its upper reach and lower reach, the division line being Interstate 95. The upper reach, as described above, contains mostly residential and agricultural land. The lower reach, to the east of Interstate is industrially developed, contains both the Four Mile and Spotsylvania Industrial Parks at the intersection of U.S. Route 1 and Courthouse Road. These parks, though not fully developed, are a large percentage of the impervious area that averages 22%. Figure 1, shown on the following page depicts the study area divided into the three major tributary subwatersheds that flow into the City of Fredericksburg.

FIGURE 1



MAJOR TRIBUTARIES OF THE HAZEL RUN WATERSHED

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REV. DATE: 11/23/93

PREVIOUS JOB NO.

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DATABASE ANALYSIS

To evaluate the appropriate comprehensive stormwater management program for Spotsylvania County, it is first necessary to collect vital information pertaining to the characteristics of the watershed itself. This report is the result of a detailed analysis of the Hazel Run Watershed and its stormwater runoff characteristics and data. The data used in this study is described in detail below.

Aerial Survey- The topography of the Hazel Run Watershed was mapped digitally by Photogrammetric Data Services, Inc. of Sterling, Virginia. Mapping compilation was completed at 1"=400' scale with 5' contours.

Stormwater features such as stream channels, lakes, ponds, and dams are included in this mapping. Digital mapping of improvements, including buildings, roads, parking lots, and the like are included to allow accurate estimates of both levels of current development and percentage of impervious ground coverage in the watershed.

Soil Mapping- Soil mapping is critical to the analysis of runoff characteristics. Highly permeable soils, which include sandy or gravelly silts, tend to allow high levels of rainfall to be absorbed into the ground, reducing the runoff from the storm event. Highly impervious soils, like many of Virginia's clays and silty clays, absorb very little rainfall, forcing higher levels of runoff, affecting the amount of rainfall that enters the main channels.

This study uses as its soil reference the *Soil Survey of Spotsylvania County Virginia*, published by the Soil Conservation Service in cooperation with Virginia Tech.

From this survey soils are categorized into four soil groups, A through D. The soils of the A group (there were none found in the study area), consist of the most highly permeable soils, while the D soils comprised of mostly impervious clays and silts.

Soils that predominate this study area are the B, C and D type soils. The D soils dominate the flood plain

regions and along the creek channels, while the B soils are generally found in the upper topography of the study.

Copies of the Soil Survey can be obtained upon request.

Hydrologic Mapping- To evaluate the runoff generated in Hazel Run, it is necessary to compile the development plan with the soil mapping to further develop runoff characteristics within each watershed. The resulting information allows for detailed analysis of the runoff trend in each watershed.

HYDROLOGIC ANALYSIS

GENERAL

To assess the conditions that exist in the Hazel Run Watershed and determine recommendations for remedies that may be needed, parameters are established and assumptions made in the analysis of the system. These parameters are used to create the model that will estimate what happens during rainfall events.

For the purposes of this study, the modeling utilizes the HEC-1 computer program, described later in this section.

One of the main assumptions of this study is to determine today's rate of flow verses the rate of flow prior to any development occurring in the watershed, including the development of ponds and lakes that exist today. The assumption is based on the premise that streams that serve the undeveloped land are adequate to handle the flows, and that those flows could be matched to current flows to determine the adequacy of today's channels. Based on the increase in flow the watershed can then be analyzed for flow attenuation alternatives.

The HEC-1 program is run for the 2, 10 and 100 year frequency storm events. Points are analyzed throughout the watershed to determine areas of increased runoff and to determine where, if any, control structures should be incorporated.

Because the primary concern of this study is that of downstream flooding in the City of Fredericksburg, four primary analysis points are chosen for study. The points represent the following stream tributaries:

1) *Hazel Run Confluence* (City of Fredericksburg)
This analysis point is the first junction point that carries the entire runoff from the study watershed.

2) *Hazel Run Tributary*
This analysis point is taken in the Hazel Run tributary just west of its confluence with the Long Branch tributary.

3) *Long Branch Tributary*
This analysis point is taken in the Long Branch just west of its confluence with the Hazel Run tributary.

4) *Altoona Subdivision* (City of Fredericksburg)
An area previously determined to have potential erosion problems, the Altoona Subdivision is adjacent to the Spotsylvania Mall tributary. A single cul-de-sac is within 30 feet of the channel.

These points are analyzed for predevelopment discharges versus the existing runoff conditions. .

METHODOLOGY

The hydrologic model used in this study is the HEC-1 Flood Analysis Program developed by the U.S. Army Corps of Engineers, for determining the peak runoff volumes and rates. The HEC-1 model is an accepted standard of the practice, and is selected because of its ability to simulate the study area as well as its ability to interact effectively with the HEC-2 Water Surface Profile program, which is used to determine the main channel flood plain.

The primary objectives in using HEC-1 are:

1) To accurately model conditions of the watershed, both existing and predevelopment.

2) To deliver a model to the County that is in the public domain that will likely remain a standard of the practice, allowing future modifications as the watershed develops.

3) To model the watershed so that many points within the watershed can be checked for flow rates and flow times.

4) To deliver a model that can be used by engineers who develop sites within the watershed, allowing them to submit development impact analyses on the watershed.

This study employs the SCS option in HEC-1 for infiltration determination and hydrograph creation. Additional information on this program is available in the HEC-1 Flood Hydrograph Package User's Manual, September 1990.

HEC-1 employs the use of information relevant to the stream morphology and makeup to calculate flows in the watershed. This data is described more fully below:

Drainage Areas

Based on the aerial topography and field verification of flow directions, the drainage areas that make up watersheds within the Hazel Run watershed are divided for input in the HEC-1 model. Drainage breaks are chosen in critical analysis points, major road crossings, and in locations where a significant change in land use occurs. Each division, or subwatershed is numbered and described in Appendix B.

Hydrologic parameters

The HEC-1 Model uses the following hydrologic input information to simulate flows in each subwatershed:

1) Channel Slope
2) Channel Hydraulic Length
3) Impervious Fraction
4) SCS Curve Number
5) Mannings Roughness Coefficient "n"
6) Basin Lag Time
7) Loss Parameters

Rainfall Information

This study uses the 2, 10, and 100 year frequency storms with 24 hour durations as the standard storms for analysis.

Reservoir Routing

For both existing and proposed reservoirs, ponds, lakes and other impoundments, the HEC-1 model simulates the outlet performance using stage-storage-discharge relationships unique to each.

Reach Routing

HEC-1 uses input that indicates the time and distance that subwatershed flows require to flow through the downstream section. This distance is not the hydraulic length of the downstream section but rather the distance of the main channel from the reach outfall to the downstream outfall.

Land Use

The land use, which tells us about the ground cover makeup, is taken

from the aerial photography of the watershed. The land use is used to determine the SCS curve number as well as the impervious fraction for the subwatersheds.

The land use is used in large part to properly subdivide (hydrologically) the watershed into its critical subwatersheds for study using HEC-1. Where possible, the watersheds are divided where the type of land use (commercial, industrial, residential) changes significantly.

The impervious fraction is the percentage of impervious surface (rooftops, parking lots, roads, etc.) taken over the entire subwatershed boundary. Within each drainage area, a ten acre square representative of the entire site is broken down into its impervious and pervious parts to determine accurate impervious fractions. This method helps to create a model that is tailored to the watershed.

Soils

Soil properties affect the runoff potential of a watershed. Permeability, or the ability of soil to absorb rainfall, contributes to reducing runoff as it increases. The soil slopes affect the amount of water that can permeate the soil. Steep slopes allow little infiltration, while flat slopes allow for higher rates of absorption. The ground cover can significantly affect the ability of rainfall to enter the soil. Brush, grass, and heavy weeds all help to hold the water to allow for infiltration, while barren ground does little to assist effective ground interception.

The soils in this study are classified by the *Soil Survey of Spotsylvania County, Virginia* published by the U.S. Soil Conservation Service. The soils are categorized into four hydrologic groups for purposes of engineering analysis. The groups are:

Group A - Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well- to excessively-drained sands and gravels. These soils can transmit water at high rates. Highly permeable.

Group B - Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. Moderately permeable.

Group C - Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes

downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission. Slightly permeable.

Group D - Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow water transmission rate. Impervious.

The groups found in the study area are listed in Appendix C.

ALTERNATIVE ANALYSIS

After analysis of the data within the watershed is performed to determine the stormwater flow rates in the main stream channels, it is necessary to look at improvement alternatives to achieve desired reductions in those rates. We determined that the rate of reduction desired for this project is to that of predevelopment levels. This will allow the stream to carry flows with no further erosion.

The first of the three improvements analyses consists of choosing multiple upland (out of major streams and floodplain) BMPs to attenuate the flows and reduce pollutant transport. The second alternative calls for major in-stream devices constructed to temporarily slow the main channel flow prior to its reaching the City of Fredericksburg. The third alternative consists of county controlled maintenance of existing lakes and ponds, while making improvements to points along the system where erosion and sedimentation are occurring.

ALTERNATIVE 1

BMPs, either as dry or wet ponds, are first considered for use as flow attenuation devices. The basins will reduce the amount of runoff from each of the watersheds served by the BMPs thereby reducing the total flow entering the City of Fredericksburg.

These basins are schematically located to maximize the value as a flood control device while minimizing the potential construction and maintenance costs. Issues such as accessibility, topography, and development percentage, all play a role in the initial locating of the potential stormwater basins.

The existing lakes and ponds that are performing stormwater attenuation functions are included as part of the BMP system. Because of this inclusion, and to ensure the continued performance of those facilities, the County will have to take over ownership and maintenance responsibility for these existing facilities. This cost of ownership is included in the cost analysis for the alternative.

The key issue regarding basin placement is that of wetland impacts. The basins will have to receive a permit from the U.S. Army Corps of Engineers if any inundation, removal, or other type of destruction to the wetland habitat will occur in the implementation of the flood control plan. Every effort will need to be taken to avoid and minimize the destruction of wetlands, and so the basins are placed out of the main channels just

upstream of the major wetland areas of the watershed.

When analyzing the hydraulic character of the watershed, it is important to note that a method to reduce the peak flows downstream is through a combination of releasing water that is currently attenuated by stormwater structures, while detaining water in other areas. This combination will reduce the "delayed peak" phenomenon that occurs on large watersheds using many control facilities. The delayed peak is a shift of the downstream peak flow conditions caused by detaining water and holding it for a period of time. In many cases, the delayed peak can actually be greater than the existing peak without detention, which in the case of this study, will not solve the problem.

The best hydraulic results occur by using the configuration of basins within the watershed shown on Figure 2 as Alternative 1 Improvements. The alternative consists of the County overtaking the maintenance and ownership responsibilities of eleven existing facilities throughout the three tributaries and constructing twelve new facilities to impede the runoff levels.

The runoff levels are reviewed downstream at the Hazel Run Confluence. The results of Alternative 1 on the watershed system is as follows:

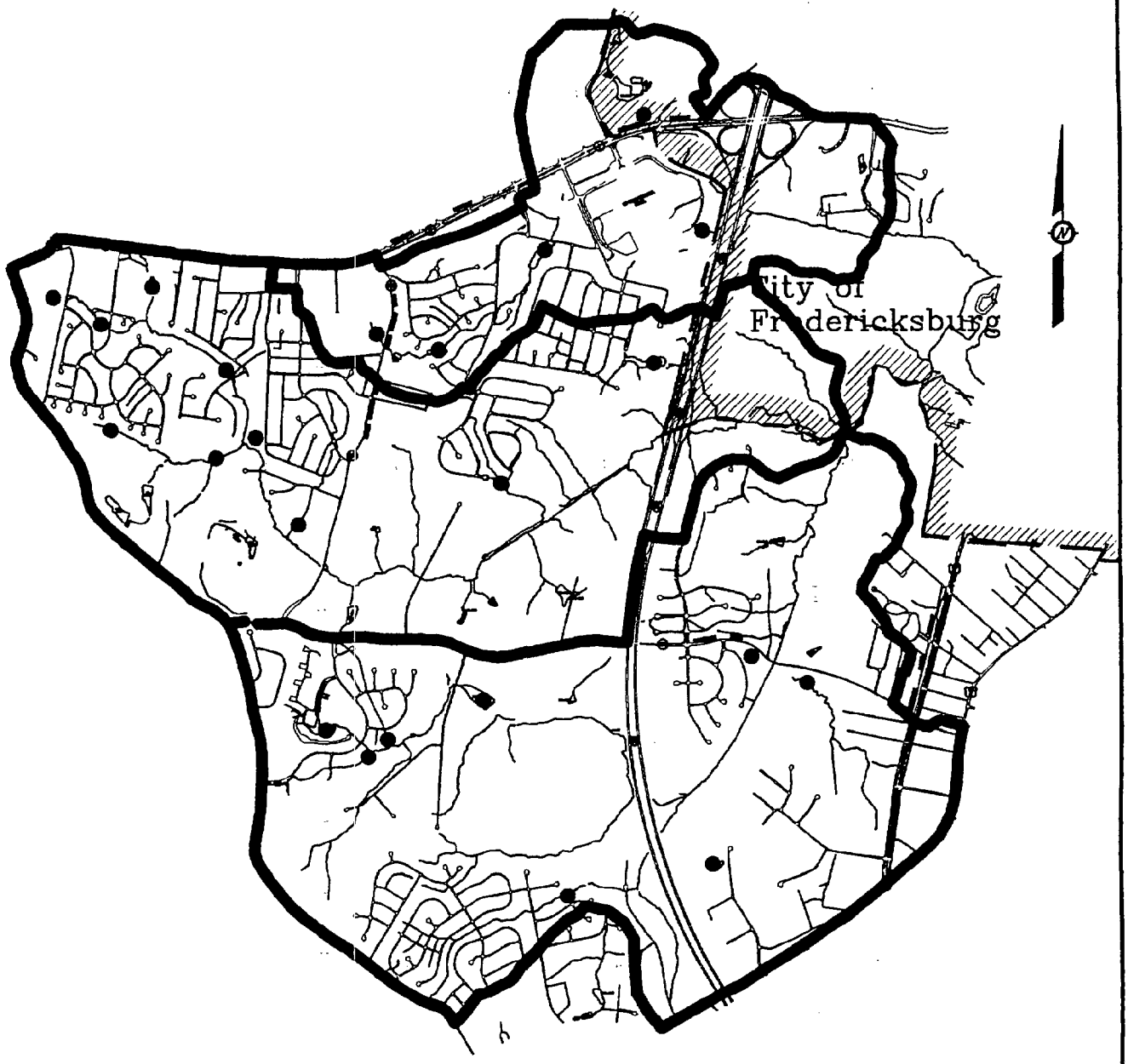
Storm Channel Peak Flow Rates (units in c.f.s.)

	2 Year	10 Year	100 Year
Undeveloped	1458	3534	6112
Existing Cond.	1887	4144	6763
With Alt. 1	1890	4202	6831

Note that the peak flows using flood control features upstream actually increased the peak flow at the confluence by approximately 1%.

In reviewing potential locations to release water currently detained, it is determined that the best hydraulic choices are those basins located closest to the tributary confluence, namely in the area of the Industrial Parks of Long Branch. While releasing these flows may have helped reduce the peak flows somewhat, the more important function that the existing basins provide, nonpoint pollution reduction, is lost. While solving one problem, a greater one is created.

FIGURE 2



Location of Improvements for Alternative 1

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ALTERNATIVE 1 COSTS

The following list is an estimate of the cost to Spotsylvania County for implementing Alternative 1. The list includes both new construction and upgrading existing facilities to properly attenuate the storms. Maintenance and estimated land acquisition costs are also included.

IMP. NO.	DESCRIPTION	LAND	CONSTR.	MAINT.
1	West of Cherry Rd. Construct dry pond	$8000	$60,000	$3000
2	East Cherry Rd. Construct dry pond	$9500	$100,000	$3000
3	Chancellor Village Improve ex. wet pond	$5000	$30,000	$3200

4	Sheraton Hills Construct pond	$8500	$90,000	$4500
5	Sheraton Oaks West Construct dry pond	$15,000	$140,000	$4500
6	SE Cherry Rd./Rte.620 Construct dry pond	$9500	$90,000	$3000
7	Salisbury Construct dry pond	$12,000	$150,000	$5000
8	Sheraton Oaks Construct pond	$9500	$100,000	$4500
9	Salem Station Construct dry pond	$8250	$70,000	$5000
10	Queen's Mill West Improve ex. dry pond	$5000	$50,000	$3500
11	Carriage Hills Improve ex. wet pond	$5000	$50,000	$4500
12	Leavell's Crossing Improve ex. dry pond	$5000	$10,000	$3000
13	Four Mile Fork Ind. Pk. Improve pond (Qin=Qout)	$5000	$16,000	$4000
14	Beauclaire Plantation Improve ex. wet pond	$5000	$10,000	$4000
15	Spotswood Heights Construct dry pond	$11,250	$90,000	$3000
16	VDOT Commuter Lot Improve ex. dry pond	$2000	$50,000	$4000
17	Rte 3/West Salem Ch. Improve basin	$8000	$70,000	$5500

18	Salem Ch. Elementary Construct dry pond	$5000	$110,000	$4000
19	Old Salem Church Improve ex. wet pond	$10,000	$50,000	$3000
20	Maple Grove/Vil.Square Improve ex. wet pond	$12,500	$50,000	$4500
21	Toys-R-Us (Fred'Burg) Improve pond structures	-	$20,000	-
22	Lower Spots. Mall Improve ex. dry pond	$10,000	$70,000	$4500
23	Maple Grove Improve ex. wet pond	$5000	$40,000	$3000
	TOTAL	**$174,000**	**$1,516,000**	
	TOTAL ANNUAL MAINTENANCE			**$86,200**

Costs associated with the implementation of this alternative are extremely high. It is estimated that approximately $1,500,000 will be required for the construction of the basin facilities in this plan. Annual maintenance costs are nearly $90,000. Neither of these two costs includes the high price of land acquisition for the nearly eighty acres of land for construction and access.

ALTERNATIVE 2

The second alternative is to reduce flows in the main channels by constructing flow constriction devices in the channels. The devices will allow base stream flows to pass through uninhibited. As stormwater flows entered the stream channel, the restrictive walls, or dam effect, will take place, reducing the flows at the outflow while storing the attenuated water temporarily in the flood plain area.

The delayed peak effect has to be checked using this alternative because it is essentially the same analysis as Alternative 1, only on a larger scale.

Alternative 2 Improvements include three flow restriction devices, one on the Long Branch tributary and two on the Spotsylvania Mall tributary. Figure 3 shows the locations. The Long Branch device is located just south of Harrison Road (Route 620), and the two mall tributary devices are located west of Salem Church Road and Interstate 95.

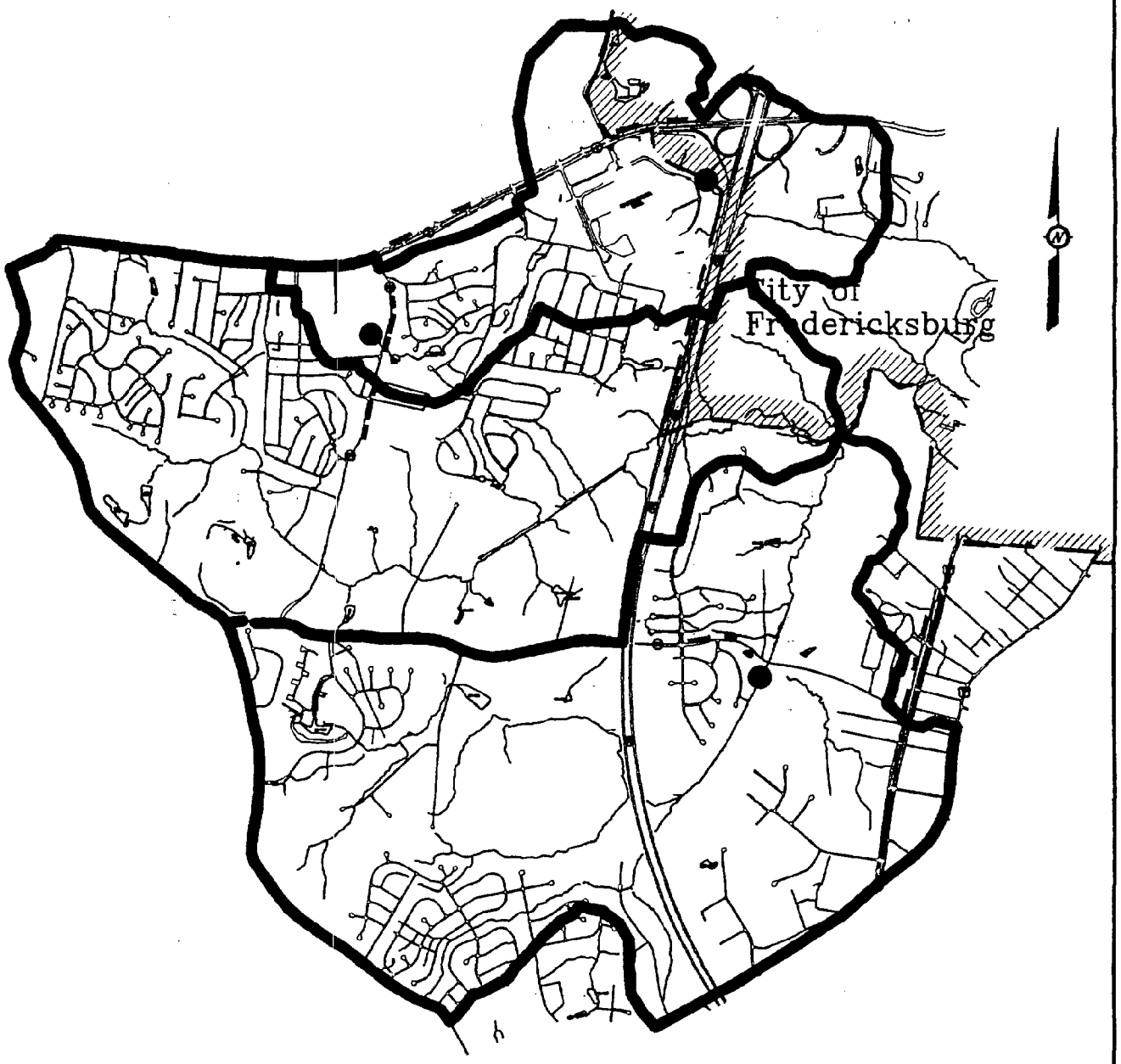
The runoff levels are reviewed downstream at the Hazel Run Confluence. The results of Alternative 2 on the watershed system is as follows:

Storm Channel Peak Flow Rates (units in c.f.s.)

	2 Year	10 Year	100 Year
Undeveloped	1458	3534	6112
Existing Cond.	1887	4144	6763
With Alt. 2	1855	4190	6741

Like Alternative 1, the results of this alternative show that with the improvements in place up stream, the flow in Fredericksburg shows little reduction, and in the case of the 10 year peak flows, shows an actual increase.

FIGURE 3



Location of Improvements for Alternative 2

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ALTERNATIVE 2 COSTS

Imp. No.	DESCRIPTION	LAND	CONSTR.	MAINT.
1	Hazel Run/Salem Elem. Sch. Construct weir upstream of road	$15,000	$90,000	$7000
2	Long Branch/Harrison Rd. Construct weir upstream of road	$30,000	$175,000	$8000
3	Spots. Mall/I-95 Crossing	$20,000	$190,000	$10,500
	TOTAL	**$75,000**	**$455,000**	
	TOTAL ANNUAL MAINTENANCE			**$25,500**

Costs for Alternative 2, while less than Alternative 1, will approach $500,000 in construction costs. Annual maintenance will add another $25,500 required for the program.

Another complicating factor of using Alternative 2 is the aforementioned wetlands issues. There is impacted wetlands at the site of the device, and a mitigation program will likely be required. Also, there is the fact that stormwater is stored, temporarily "flooding" a portion of land (primarily wetlands). It is uncertain what the permitting position of the Corps of Engineers might be, but they will likely consider the limits of inundation to be wetland impacts. This position will make in-stream restrictive devices difficult and costly to permit and construct.

ALTERNATIVE 3

In evaluating the options to achieve the goals of this study, we again turn to the major component of the problem. Erosion and sedimentation problems are occurring in and near Altoona, a subdivision located in the City of Fredericksburg.

Using results obtained by studying the first two alternatives, we next look at Alternative 3 Improvements. This involves no new basin construction, taking over major existing facilities, and stabilizing the downstream reach of the Spotsylvania Mall Tributary to alleviate the erosion problems.

The reason for no new basin construction is as noted in the first two alternatives. Delayed peaks caused by the basins do not suit the stated goals of the flood control plan. The basins are a costly, and more importantly, ineffective solution to the Fredericksburg erosion problem.

The county will maintain the existing major facilities under Alternative 3 Improvements. This will ensure the continued flow character of the watershed at its current level. These levels will remain at current levels by restricting future development from adding to the downstream peak flow.

Stabilizing Altoona Subdivision

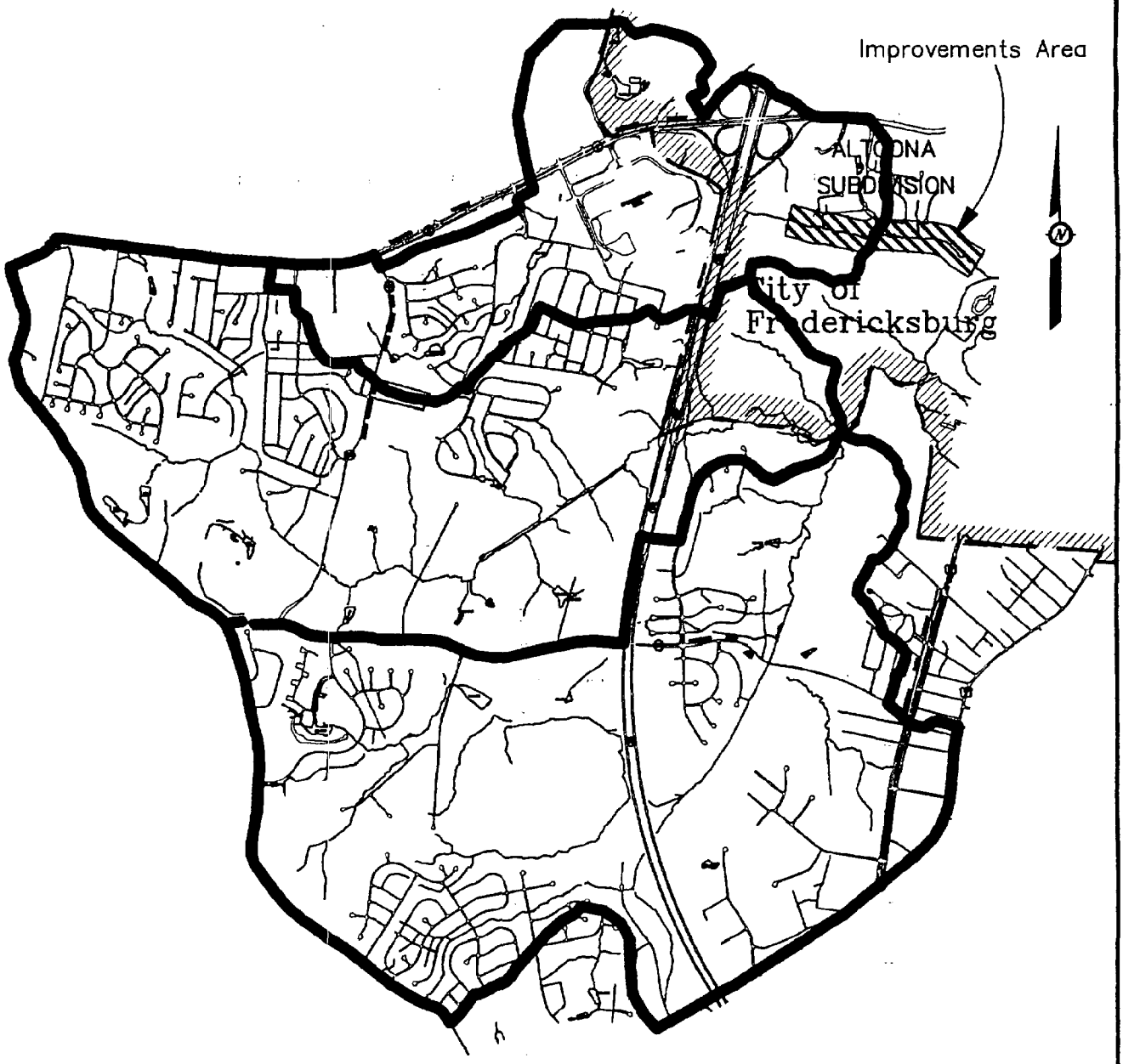
Corrective measures to low level flood damage and erosion occurring in the Spotsylvania Mall outfall include the stabilization of the naturally erosive stream banks. As a result the commercial development in the watershed, the minor storms produce more runoff. It is these low volume storms that, occurring at higher frequencies, have caused some of the erosion problems that exist in the stream. The highly erosive nature of this fall line channel increases its susceptibility of degradation. To effectively protect the channel, stabilization must be provided to handle these low flow storm events.

The stabilization of the Spotsylvania Mall tributary is made beginning upstream east of its crossing Interstate 95 down to its confluence with Hazel Run. Most of the problem areas occur downstream of the Altoona Subdivision. The measures consist of large diameter rip rap (18" min. diameter) lining the main channel for a distance of approximately 4,000 feet. Figure 4 shows the location where the stream bank

improvements need to be made.

The costs, aside from land acquisition where needed, is approximately $120,000 for stream stabilization in the mall tributary, and maintenance costs for the stream improvements is estimated to be less than $5,000 per year.

FIGURE 4



Location of Improvements for Alternative 3

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ENGINEERS * ARCHITECTS * SURVEYORS	
711 N. COURTHOUSE RD.	RICHMOND, VA
8803 STAPLES MILL RD.	HENRICO CO., VA
4411 CROSSINGS BLVD.	PRINCE GEORGE, VA.
DATE: 7-14-93	SCALE: 1"=3000'
DRAWN BY: PM	
CHECKED BY:	CALC. CHK.:
PREVIOUS JOB NO.	JOB NO.: 15321

RECOMMENDATIONS

Alternatives 1 and 2 involve large amounts of land acquisition, high construction and ongoing maintenance costs. In place, these improvements only reduce peak flows at the Hazel Run confluence by 1-2%, in some cases actually increasing the downstream peak rate. In all, these alternatives do not serve the stated goals of the study.

Alternative 3 satisfies the goals of the study with one exception. It reduces the erosive effect of the higher frequency lower-flow storms that are causing some problems in the Altoona Subdivision area, while maintaining the integrity of the watershed as it is. The type of erosion protection in the mall watershed will also promote wetland growth. Sediment that is deposited among the stone will create a bedding for many plant species that can filter pollutants as the stormwater flows through, creating a desirous dual benefit for both the City of Fredericksburg and the County of Spotsylvania.

What Alternative 3 does not do is decrease the current runoff levels, one of the initial goals. However, since the overall increase in the high volume storms from predevelopment conditions is between 10-15%, and because no major erosion problems have been experienced in the rest of the watershed, protection for the future is best handled through stormwater ordinance measures.

Protecting Future Development Flood Concerns

Effective flood control in Hazel Run depends on an effective approach to the future development techniques used and required by Spotsylvania County. While a developer may install an onsite Best Management Practice (BMP) to control the immediate downstream channel, he may actually accentuate the flows at the point where the stream enters the City of Fredericksburg. An effective development plan must therefore be sensitive to both site and regional constraints.

This is best achieved through a stormwater management ordinance that will require new development to investigate its impacts on not only its next door neighbor, but in the City of Fredericksburg. This will cause the County of Spotsylvania to keep a master version of this stormwater management study available for use by engineering consultants in their impact assessments. By implementing this ordinance, Spotsylvania County will be able to protect its own streams, but will be acting in good faith to prevent any problems to her downstream neighbor, the City of Fredericksburg.

APPENDIX A

MAIN CHANNEL FLOWS

Main Channel Analysis - HEC-1 Model

The table below shows a comparison of the discharges found in critical areas of the study area. Both predevelopment and current levels are shown.

Analysis Location (all discharges are in c.f.s.)	Predeveloped	Current	% Increase
Hazel Run Confluence			
2 Year	1458	1887	29%
10 Year	3534	4144	17%
100 Year	6112	6763	10.5%
Hazel Run Trib.			
2 Year	508	573	13%
10 Year	1199	1341	12%
100 Year	2082	2352	13%
Long Branch			
2 Year	694	907	30%
10 Year	1668	1932	16%
100 Year	2819	3049	8%
Altoona Subdivision			
2 Year	542	817	50%
10 Year	1277	1503	17%
100 Year	2132	2372	11%

APPENDIX B

SUBWATERSHED DESCRIPTIONS

SUBWATERSHED DESCRIPTIONS

The following section describes the subwatersheds used in the HEC-1 model that make up the study area. The subwatersheds are grouped into three categories corresponding to where they flow. They are the Hazel Run, Long Branch, and Spotsylvania Mall tributaries.

Hazel Run Tributary - 1000 Series

Subwatershed ID Number	*Location Description*
1000	West of Cherry Road
1001	East of Cherry Road
1002	Chancellor Green
1003	Chancellor Village/Five Mile Fork
1004	Chancellor Green
1005	Sheraton Hills
1006	Sheraton Hills
1007	Sheraton Oaks West
1008	Southeast Cherry Road/Harrison Road
1009	Salisbury
1010	Chancellor Landfill
1011	Sheraton Oaks
1012	Hazel Run/West of Salem Church Road
1013	Hazel Run/East of Salem Church Road
1014	Hazel Run/East Twin Springs Estates
1015	Maple Grove
1016	Hazel Run/Maple Grove Outfall

1017	Hazel Run/Maple Woods Outfall
1018	Hazel Run/West of Interstate
1019	Waverly Village
1020	Waverly Village/Interstate
1021	Hazel Run/East of Interstate
1022	Hazel Run Outfall

Long Branch Tributary - 2000 Series

Subwatershed ID Number	*Location Description*
2000	Summerlake
2001	Salem Station
2002	Queens Mill West
2003	Queens Mill East/Carriage Hills West
2004	Carriage Hills East
2005	Long Branch/West of Interstate
2006	Leavell's Crossing
2007	Rollingwood Drive
2008	Four Mile Fork Industrial Park
2009	Long Branch/East of Interstate
2010	Spotsylvania Industrial Park West
2011	Long Branch/Spotsylvania Industrial Park
2012	Long Branch
2013	Beauclaire Plantation
2014	Four Mile Fork Shopping Center

2015	Grainger Mobile Home Park
2016	Spotswood Heights/South Route 620
2017	Long Branch/Kingswood
2018	Long Branch
2019	Long Branch Outfall

Spotsylvania Mall Tributary - 3000 Series

Subwatershed ID Number	*Location Description*
3000	Upper Sheraton Hills
3001	VDOT Commuter Lot
3002	Sheraton Oaks/Salem Elementary School
3003	Salem Elementary School
3004	Old Salem Church
3005	Maple Grove United Methodist Church
3006	Village Square/Upper Spotsylvania Mall
3007	Toys-R-Us/Shannon Green
3008	Maple Grove/Lower Spotsylvania Mall
3009	Lower Spotsylvania Mall Outfall
3010	Interstate East (in City of Fredericksburg)
3011	Gateway Shopping Center (in City of Fredericksburg)
3012	Altoona Subdivision (in City of Fredericksburg)
3013	Greenbrier Shopping Center (in City of Fredericksburg)
3014	Altoona West Subdivision (in City of Fredericksburg)

APPENDIX C

WATERSHED SOILS

The following is a list of the soils found in the watershed study area as compiled by the SCS Soil Survey of Spotsylvania County, along with their soil number and hydrologic group..

Soil Number	Soil Description	Hydrologic Group
1B	Abell	B
2B	Altavista	C
4C2	Appling	B
4D2	Appling	B
5	Aquults	D
12B	Cecil	B
14B	Colfax	C
17C	Dystrochrepts	D
17D	Dystrochrepts	D
17E	Dystrochrepts	D
18B	Emporia	C
18C	Emporia	C
21B	Faceville	B
21C2	Faceville	B
23	Fluvaquents	D
24	Goldsboro	B
25C	Kempsville	B
27	Louisburg	B
29C2	Masada	C
30B	Mattaponi	C
31C2	Mattaponi	C
34B	Partlow	D
36B	Savannah	C
37B	Spotsylvania	C
44	Udorthents	45
B	Udorthents	D
46	Interstate	D

For more information regarding the soils in this study, refer to the *Soil Survey of Spotsylvania County, Virginia*.